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ADVANCE REPORT

on the

SEDIMENTATION SURVEY OF BARCROFT RESERVOIR

ALEXANDRIA, VIRGINIA

September 17, 1937 - March 8, 1938

by

Farrell F. Barnes

UNITED STATES DEPARTMENT OF AGRICULTURE
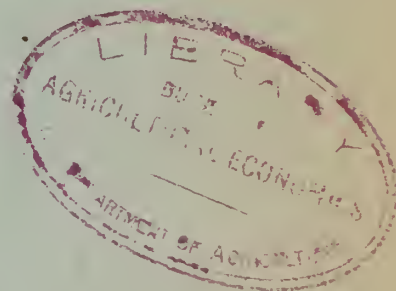SOIL CONSERVATION SERVICE
Washington, D. C.
H. H. Bennett, Chief.

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Division of Research

ABSTRACT

The sedimentation survey of Barcroft Reservoir was made as part of a Nation-wide study of rates and causes of reservoir silting, especially as influenced by soil erosion and land use.

Barcroft Reservoir, a reserve municipal water supply for Alexandria, Va., is a 1,847-acre-foot semichannel reservoir on Holmes Run about 6 miles northwest of Alexandria. Its drainage basin, 14.5 square miles in area, lies near the eastern edge of the Piedmont Plateau and is characterized by rolling to hilly topography and yellowish-brown loam soils developed principally on crystalline rocks. The area is now undergoing only slight sheet erosion and practically no gullying. About half of the area is in woods and brush, a fifth is cultivated, and the remainder is in pasture and urban areas. The cultivated land is devoted largely to corn but includes several orchards and evergreen nurseries. Much of the land in this region has probably been cultivated during one or more periods within the last 200 years.

The bulk of the reservoir sediment consists of somewhat sandy silt, in which there is a progressive increase in average grain size toward the head of backwater. The deposits are rather evenly distributed over the basin, the average thickness in cross section generally ranging between 0.5 and 1 foot, except in the delta areas where it approaches 2 and 3 feet. The deposits have been derived largely from almost imperceptible sheet erosion, particularly of cultivated areas, and to a very minor extent from stream-bank and gully erosion.

The survey revealed that 85 acre-feet (13,700 cubic yards) of sediment had accumulated in the reservoir at an average rate of 3.7 acre-feet per year, which is equivalent to about 17 cubic feet per acre of drainage area. The loss of original storage, however, has been only 0.2 percent per year, or 4.6 percent to the date of survey. These data indicate that storage loss through silting is not a serious problem in this reservoir under existing conditions.

INTRODUCTION

This report is one of a series of advance reports on reservoir silting investigations made by the Section of Sedimentation Studies, Division of Research, Soil Conservation Service. Each

reservoir survey is a part of a Nation-wide study of the condition of American reservoirs with respect to storage reduction by silting. The ultimate objective of these studies is to determine rates and causes of reservoir silting, in order to derive a practical index to (1) the useful-life expectancy of existing or contemplated reservoirs, and (2) differences and changes in regional erosion conditions as influenced both by natural factors and by land use.

Barcroft Reservoir was surveyed during parts of the period September 17, 1937 to March 8, 1938, by a field party consisting of L. H. Barnes, chief of party; M. P. Connaughton, geologic aide; E. H. Moser, Jr. and A. T. Talley, engineering aides; and two temporary assistants. L. M. Seavy assisted in establishing the horizontal control by triangulation. A preliminary examination of the reservoir and arrangements for the survey were made by L. M. Glymph, Jr. M. P. Connaughton furnished descriptive notes on the sediment deposits and assisted the writer on a reconnaissance of the drainage basin.

Acknowledgment is made of the generous cooperation of officials of the Alexandria Water Company, particularly H. S. Richards, superintendent, and A. D. Kirby, caretaker at the reservoir, during the course of the survey.

GENERAL INFORMATION

Location: (fig. 1).

   State: Virginia.

   County: Fairfax.

   Distance and direction from nearest city: 6 miles northwest of
      Alexandria, Va.

   Drainage and backwater: Holmes Run and its tributary, Tripps
      Run, which unite one-fourth mile above the dam. From the dam
      Holmes Run flows southeastward about 3 miles and joins Back
      Lick Run to form Cameron Run, which continues nearly due east-
      ward 3 miles to enter the Potomac River at Alexandria.
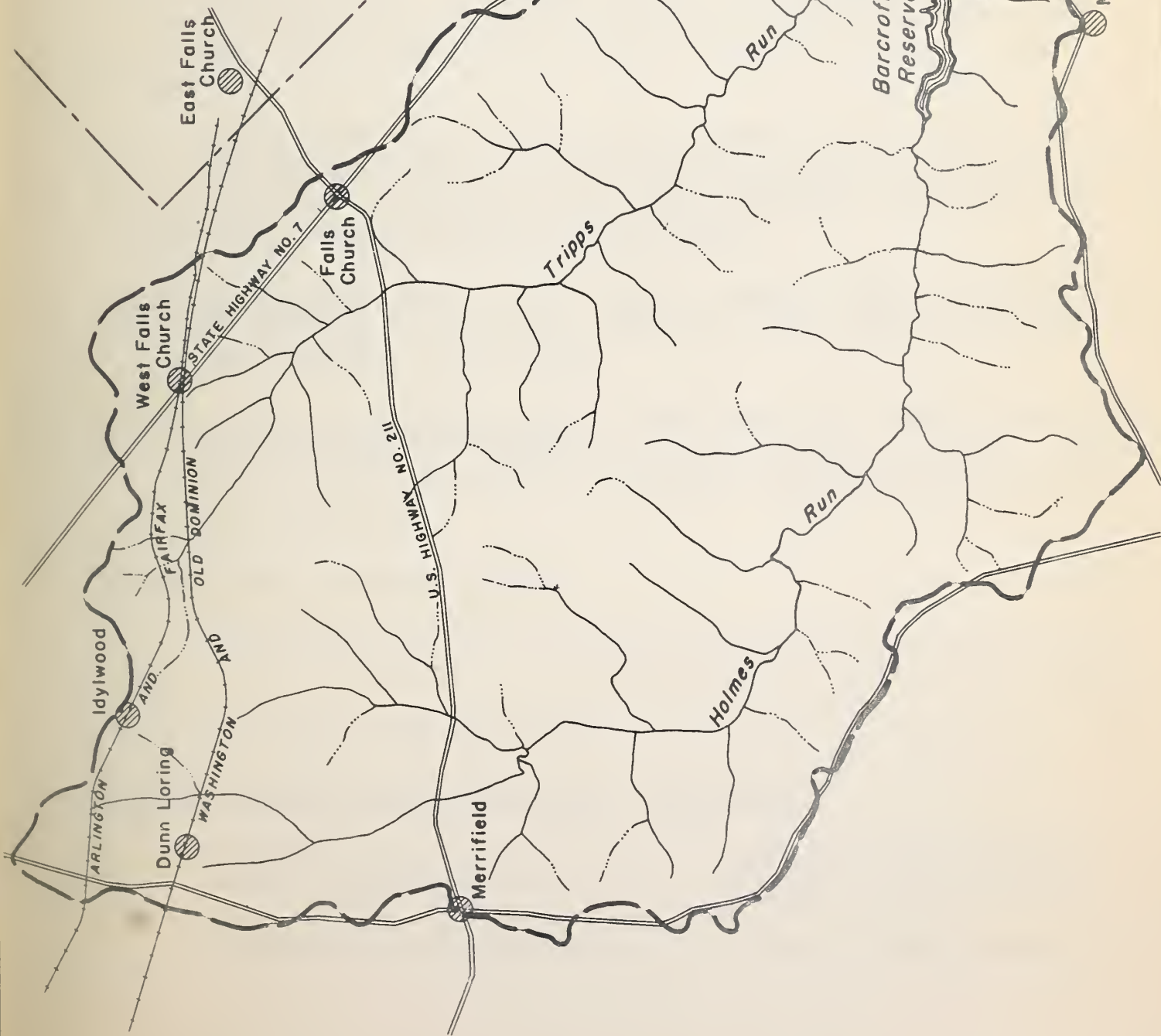
Ownership: Alexandria Water Company.

Purpose served: Reserve water supply for the city of Alexandria.

Figure 1

BARCROFT RESERVOIR
and
DRAINAGE AREA
ALEXANDRIA, VIRGINIA

LEGEND

Drainage Area Boundary
Reservoir
Highways
Railroads

Scale in Miles
1/2   0

ARLINGTON CO.
FAIRFAX CO.

East Falls
Church

West Falls
Church

STATE HIGHWAY NO. 7

Falls
Church

Tripps

Run

Idylwood

FAIRFAX
ARLINGTON AND.

OLD DOMINION

WASHINGTON AND

Dunn Loring

U.S. HIGHWAY NO. 211

Merrifield

Holmes

Run

Barcroft
Reservoir

Dam

Baileys
Crossroads

Mt. Pleasant

0-2242

Description of dam.

The reservoir is impounded by a concrete and cyclopean-masonry dam about 400 feet in length and 63 feet in maximum height above the stream bed. The spillway section, in the center of the dam, rises about 57 feet above the stream bed and has a total length of 200 feet; but its crest, being interrupted by the outlet tower, has a net length of only about 180 feet. The spillway crest is 205 feet above mean sea level. The upstream face of the dam is vertical, and the downstream face has a slope of about 0.7 to 1, modified by a concave apron the full length of the base, and by a convex crest in the spillway section which is thus ogee-shaped in cross section.

During dry seasons water is released from the reservoir through three gates approximately 8, 13, and 33 feet, respectively, below spillway level. This water passes on downstream to augment the combined natural flow of Back Lick and Holmes Runs at a point just below their junction where water is diverted into the city pipe-lines.

The original cost of the dam, as carried on the books of the water company, was $237,708. The reproduction cost in 1930, excluding cost of land and of engineering or other structural overheads, was estimated by company engineers at $450,000.

Period of storage: Date storage began: January 1915. Average date of sediment measurements: February 1938. Age at date of measurements: 23.1 years.

Length of lake at spillway stage: Dam to head of backwater on Holmes Run: 1.4 miles. Length of Tripps Run arm: 0.7 mile. Neither arm had been appreciably shortened by delta-building at the time of survey.

Area of lake at spillway stage: Acres

Original.. 115.4
At date of survey.. 115.0

Reduction by sedimentation.. 0.4

Storage capacity to spillway level: Acre-feet

Original.......................   1,847 (601,844,950 gals.)
At date of survey............   1,762 (574,147,700 gals.)

Reduction by sedimentation...   85 (27,697,250 gals.)

General character of reservoir basin.

In general outline Barcroft Reservoir resembles a forked tree limb with two very crooked, gnarled branches (fig. 2, following p. 13). The lake varies considerably in width, each arm having numerous constrictions separating wider areas. The Holmes Run arm varies in width from less than 200 feet in segment 32 to 700 feet in segment 25, averaging about 430 feet. The Tripps Run arm varies from less than 200 feet in segment 14 to 500 feet in segment 19 and averages about 360 feet.

The typical cross section of the basin is that of a trough with moderately sloping sides and a comparatively flat bottom. The side slopes average about 25 to 30 percent but tend to become less toward the heads of both arms. The submerged flood plain has an average width of about 200 feet throughout most of the lake, although it narrows to 100 feet or less, but rarely vanishes, at the numerous constrictions and widens to nearly 300 feet at the extreme heads of both arms.

The original channel of Holmes Run within the limits of the reservoir had a very uniform gradient averaging about 36 feet per mile. Tripps Run, on the other hand, had a convex profile, the average gradient being 33 feet per mile in the upper half of the arm (above range R17-R22) and 83 feet per mile in the lower half.

Barcroft Reservoir is intermediate between the basin and channel types of reservoir. In plan it has the general appearance of a channel reservoir, being relatively long and narrow, but in cross section it is seen to have considerable over-bank storage on the submerged flood plain. The original storage capacity per square mile of drainage was 127 acre-feet, which is far above the average for typical channel reservoirs.

Area of drainage basin: 14.5 square miles, as planimetered from the Washington and Vicinity topographic map (U. S. Geol. Survey, scale 1/31,680, 1932.).

General character of drainage basin.

Geology.--The drainage area of Barcroft Reservoir (fig. 1) lies on the Piedmont Plateau, just west of the Fall Line which separates it from the lower-lying Coastal Plain. About one-third of the area, mainly in the headwaters, is underlain by the Wissahickon schist, a pre-Cambrian formation consisting of chlorite-muscovite schist and some thin layers of quartzite. The lower two-thirds of the drainage basin is underlain by pre-Cambrian granites, gneisses, and diorite. A few small areas of unconsolidated marine deposits of sand, gravel, and clay, Cretaceous and younger in age, extend into the area near the reservoir and also occur in the extreme headwaters.
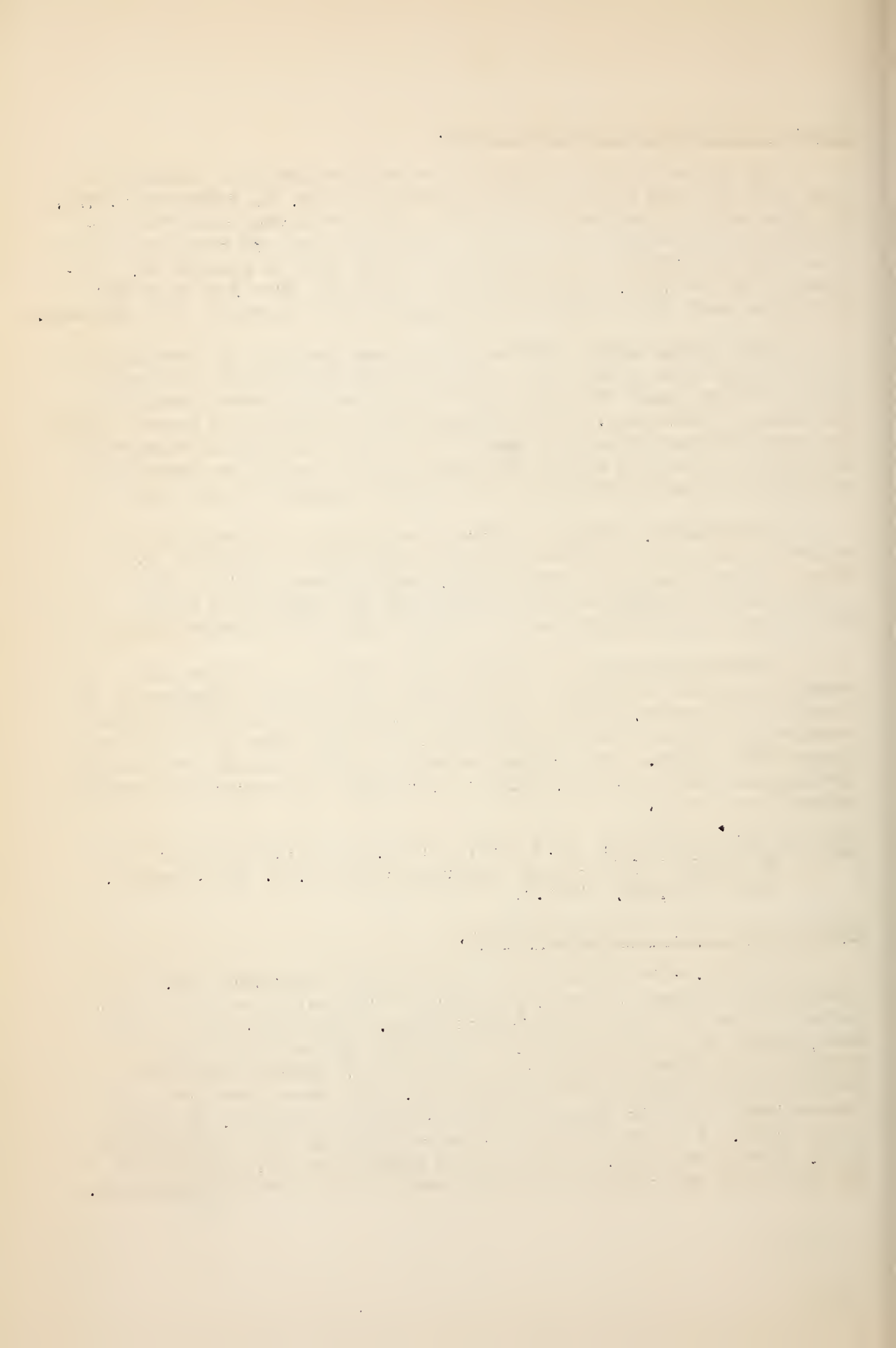
The pre-Cambrian formations are generally covered by a soil mantle several feet deep, bedrock being exposed only on the steeper slopes, chiefly near the reservoir. The soils on the Coastal Plain sediments are generally thinner, layers of gravel or impervious clay lying in many places within 2 or 3 feet of the surface.

Topography and drainage.--The topography of this area in general is moderately rolling to hilly, although considerable areas of undulating to gently rolling topography occur on the main divides. The average relief is about 100 feet, although elevations range from 200 feet at the reservoir to nearly 500 feet on the headwater divide.

The drainage system is well developed and typically dendritic. The valleys of Holmes and Tripps Runs are rather narrow and gorge-like near the reservoir; but tend to widen and become shallower headward. Flood plains, generally 300 to 500 feet wide, extend along the main streams and many of the larger tributaries.

Soils.[1]--The soil types and their relative extent in the drainage area, as shown on the soil map of Fairfax County, are as follows:

	Percent
Chester loam	53.6
Manor loam	18.9
Congaree silt loam	8.9
Sassafras gravelly loam	6.7
Leonardtown silt loam	5.3
Leonardtown loam	2.9
Sassafras loam	1.9
Louisa loam	1.8
Total	100.0

The Chester, Manor, and Louisa loams are developed on the crystalline rocks of the Piedmont, and the Leonardtown and Sassafras soils in this area on remnants of Coastal Plain sediments within the Piedmont.

The Chester loam, derived from gneiss, schist, and granite, has a brown to brownish-gray friable loam or silty clay loam surface soil and a yellow to yellowish-brown clay loam or friable clay

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[1]Carter, W. T., and Yingling, C. K., Jr. Soil Survey of Fairfax and Alexandria Counties, Virginia. U. S. Dept. Agr., Bur. Soils Field Oper. 1915, Rept. 17: 299-337, 1919.

subsoil. This soil has weathered deeply, the parent rock rarely being exposed and then only on the steepest slopes. It lies on gently to strongly rolling topography. The type is well drained, and on the steeper slopes it is subject to severe erosion when not protected by growing crops or other vegetation. This soil is the most productive and extensively cultivated type in the region.

The Manor loam, derived from mica schists, has a reddish-brown to yellowish-brown friable, mellow surface soil, which usually contains sufficient fine mica flakes to give it a smooth feel. The subsoil is a light-red to reddish-yellow or reddish-brown friable micaceous clay loam or light friable clay, in which the mica content and red color increase with depth. This soil also has weathered deeply, and covers the parent rock on all but the steepest slopes. It ranks close to the Chester loam in agricultural importance.

The Sassafras gravelly loam, derived from unconsolidated marine sediments, consists of a light-brown or yellowish gravelly loam underlain by a yellow or yellowish-brown gravelly clay. It occurs as small strips or patches on steep to gentle slopes and is unimportant agriculturally, being chiefly in woods.

The Leonardtown silt loam, derived from unconsolidated marine sediments, has a light-brown or yellowish surface soil and a yellow or brownish-yellow friable silty clay loam subsoil, and it characteristically has a gravel substratum usually at a depth of 3 feet or more. It lies on the nearly level, poorly drained uplands adjacent to the reservoir, where about half of the type is in cultivation.

The Congaree silt loam, developed on alluvial deposits on the flat-surfaced, locally marshy first bottoms, has a brown silty loam or silt loam surface soil and a grayish-brown subsoil ranging from loam or silt loam to friable clay. Fine mica flakes are abundant in both the surface soil and subsoil. This type is mainly in woodland and pasture.

The remaining soils represented in this area--namely, the Leonardtown, Louisa, and Sassafras loams--are of very limited extent and consequently are of little importance.

Erosion conditions.--A brief examination of the drainage area leads to the conclusion that sheet erosion is taking place at only a moderate rate. Practically no gullies exist, as shown both by field observation and by careful examination of aerial photographs of the area. Gullying was noted at only one point, along a steep road grade about 1 mile southeast of Falls Church, where run-off from roadside ditches had cut deep into the soft gravelly formation exposed in the road cut.

The only indications of bank erosion, found either in the field or on aerial photographs, were noted on Tripps Run about 1 mile south of Falls Church. For a distance of about 1,500 feet the meandering stream has cut away its grass-covered flood plain in a strip about 50 feet wide and to a depth of 2 to 3 feet.

In general, erosion in this drainage area is slight, chiefly because more than 80 percent of the area is protected either by a forest or brush cover or, in abandoned fields, by a heavy growth of grass, weeds, or shrubs. Also, a large part of the cultivated land lies on the more gently sloping uplands where accelerated erosion is least likely to occur.

Land use.--The following approximate figures on land use were obtained by rough measurement of aerial photographs of the drainage area taken in 1937. Distinctions of land use types were checked by a brief examination of the area in the summer of 1938.

	Percent
Woods and brush..	53
Pasture (including farmsteads and urban areas).................	29
Cultivated..	18
Total drainage area..	100

Probably the greater part of the cultivated land is devoted to corn, although considerable areas are in orchards and evergreen nurseries.

A large part of the areas now overgrown with brush and woods has doubtless been cultivated in fairly recent years, and most of the drainage basin, except the steeper slopes, has probably been cultivated during one or more periods within the last 200 years.

Mean annual rainfall: 38 inches at the United States Weather Bureau station at Great Falls, about 10 miles north-northwest of the drainage area. Available records of annual rainfall at a gage installed at the dam in 1934 are as follows:

Year	Inches
1935..	29.16
1936..	35.42
1937..	47.80
1938 (to December 20)..	37.75

Draft on reservoir.
_____

No record is kept of the amount of water withdrawn from the reservoir. Most of the time natural overflow is adequate, and only in dry seasons are the outlet gates opened. The reservoir was drawn down to a maximum of 20 feet below spillway level in 1930, but in ordinary years the draw-down does not exceed 2 feet. The population supplied by the combined flow of Holmes and Back Lick Runs was about 37,000 in 1938.

METHOD OF SURVEY

Field work consisted primarily of mapping the shore line at spillway level and measuring sediment and water depths at close intervals on 41 cross-section ranges (fig. 2, following p. 13). For horizontal control in mapping shore line and locating ranges, a triangulation system of 52 stations was expanded from a 1,030-foot base line extending along the east shore near the dam. This system was supplemented by 13 plane-table stations established by stadia at the heads of the main arms and the larger tributaries. All elevations were determined from the water surface, the elevation of which was checked by gage readings at the dam. The shore line was mapped by plane table and telescopic alidade on a scale of 1 inch to 200 feet.

Soundings and direct measurements of sediment thickness were made on each range, following the range method of survey developed by Eakin.[2] Measurements of sediment thickness were made with the 6- and 10-foot silt-sampling spuds. In some areas considerable difficulty was experienced in distinguishing lake sediment from the underlying valley soils; however, where there was no distinct contrast between the two types of material, the old soil line was usually marked by a zone of rootlets which, together with slight differences in compaction, color, or texture, defined the bottom of the lake deposit.

The old valley soils beneath the sediment range in texture from very sandy loam to sandy clay, and in color from gray to yellowish brown and reddish brown. Medium to coarse gray angular quartz sand was encountered in the old channel.

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[2] Eakin, H. M. Silting of Reservoirs. U. S. Dept. Agr. Tech. Bull. 524: 25-28, 129-135, 1936.

As a basis for future resurveys of the reservoir, all range
ends and cut-in stations were permanently marked with standard SCS
bronze tablets which were stamped with the station numbers and set
in concrete bases. It will thus be possible to resound the same
ranges to check future sedimentation in the reservoir.

SEDIMENT DEPOSITS

Character of Sediment

The deposits in Barcroft Reservoir range from slightly sandy
micaceous silt near the dam to sand, locally mixed with considerable
silt and organic matter, in the deltas at the heads of the principal
arms. Sand in varying proportions occurs from the dam to the head
of the Holmes Run arm, but very little sand is present in the lower
half of the Tripps Run arm. In both arms, however, there is a pro-
gressive increase in average grain size toward the upper end. Coarse
sand occurs in small deltas at the heads of many of the minor arms
formed by the comparatively steep tributaries.

The color of the sediment ranges from dark gray to various
shades of yellowish and brownish gray. The sediment on Tripps Run
is prevailingly dark gray, whereas that on Holmes Run is character-
istically tinged with yellow or brown.

The bulk of the reservoir deposits--with the exception of
the relatively pure silt near the dam, the comparatively clean sand
in the delta areas, and the upper few inches of sediment throughout
the lake--are unusually compact, as shown by their resistance to
penetration with the silt-sampling spud. This firmness cannot be
due to compaction resulting from exposure and drying, because most
of the sediment lies below the limit of maximum draw-down; neither
can it be due to the weight of overlying sediment, as the deposits
are rarely more than 2 to 3 feet thick, an insufficient depth to
produce appreciable compaction of even the bottom layers of sediment.
The compactness of the deposits appears to be more closely related
to the character of the sediment itself. It is well known that
particles of diverse sizes form a more compact, resistant mass than
particles of uniform size, whether they be coarse or fine. The
relatively compact sediment making up the bulk of the reservoir
deposit consists of a mixture of sand, silt, and clay, whereas the
soft silt near the dam and the loose sand in the delta areas are
fairly homogeneous in texture. The layer of soft, yielding sedi-
ment, 0.2 to 0.6 foot in thickness, that was found overlying the
compact deposits appeared to be newly added material in which com-
paction had barely started.

Distribution of Sediment

The general distribution of sediment in Barcroft Reservoir is graphically illustrated in figure 3, showing average sediment thicknesses--obtained by dividing the cross-section area of the deposit by the lake width--on each range across the main channel of both arms and the lower basin. As the average thickness is a function of both the lake width and the cross-section area, graphic representations of these factors are included in the diagram so that the relative importance of each in determining the average thickness may be readily observed. Figure 3 reveals that the reservoir sediment is rather uniformly distributed over most of the basin, although it increases markedly in thickness in deltas at the heads of the two arms. It is apparent also that sedimentation has been somewhat heavier on Tripps Run than on Holmes Run. This fact is emphasized by table 1, which shows that the Tripps Run arm, including all the lake volume above the forks (range R9-R10), has not only received a greater average thickness of sediment but has lost a considerably higher proportion of its original storage capacity than either the Holmes Run arm above the forks (range R8-R10) or the lower basin.

Table 1.--Distribution of sediment in Barcroft Reservoir

Section	Original capacity	Sediment volume	Capacity loss	Surface area	Average sediment thickness
	Acre-feet	Acre-feet	Percent	Acres	Feet
Tripps Run arm.................	429	32	7.5	32.2	1.0
Holmes Run arm.................	820	39	4.8	57.0	.7
Lower basin....................	598	14	2.3	26.2	.5
Total reservoir............	1,847	85	4.6	115.4	0.7

The lateral distribution of sediment in various parts of the reservoir is illustrated by the cross sections in figure 4, which show that the deposits invariably thicken progressively toward the channel. The deltas are characterized by exceptionally thick deposits and by natural levees bordering the channel.
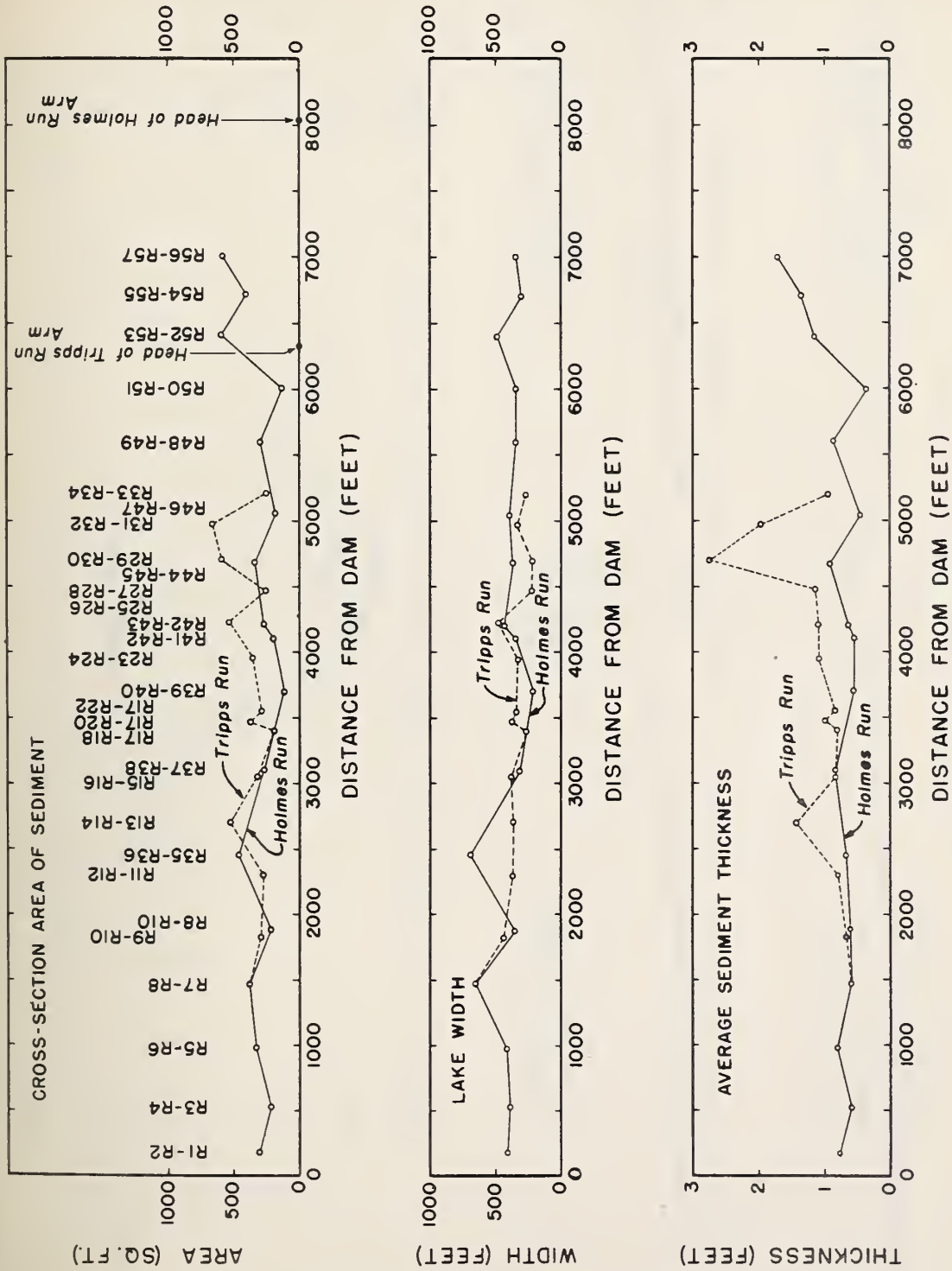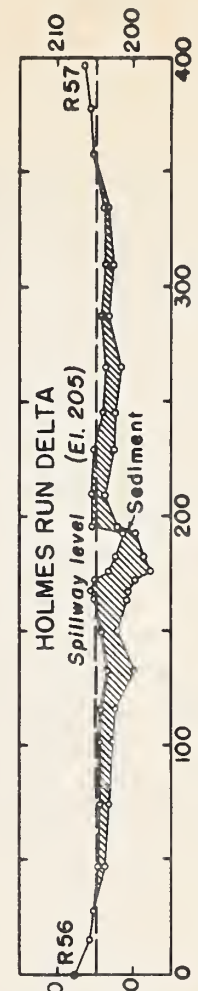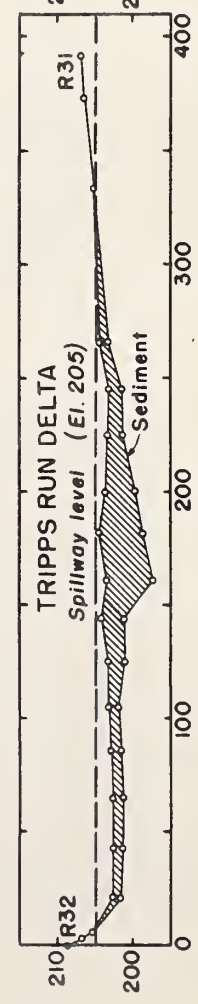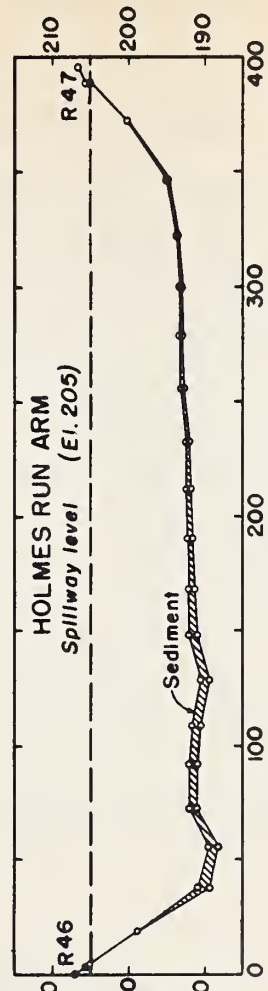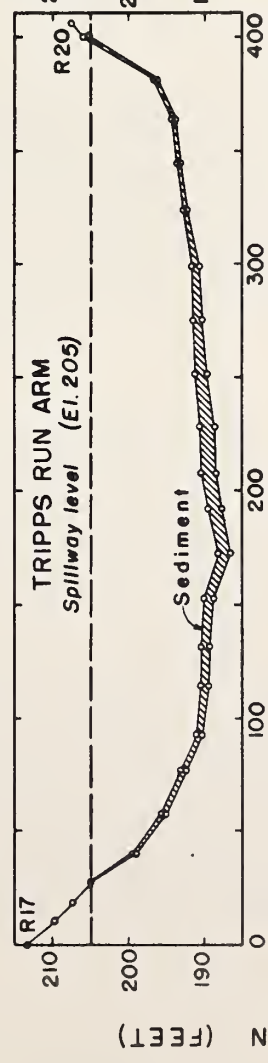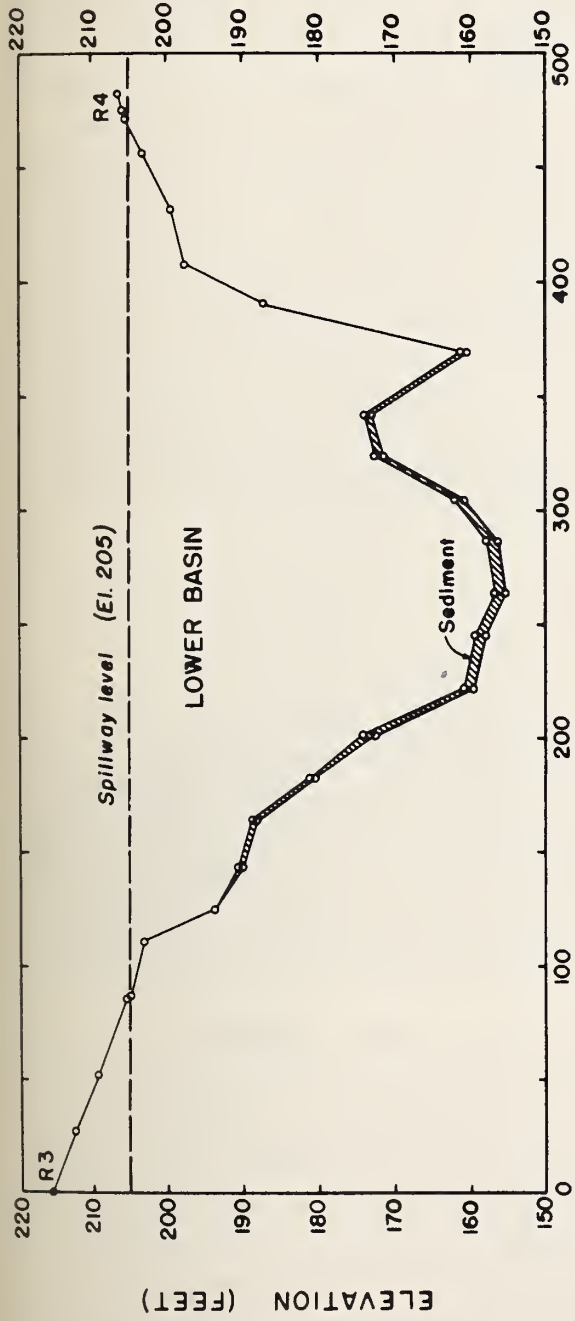
Figure 3 - Curves showing cross-section area of sediment, lake width, and average sediment thickness on ranges across the main arms of Barcroft Reservoir.

O-2455

Figure 4 - Representative Cross Sections of Barcroft Reservoir

0-2454

Origin of Sediment

A reconnaissance examination of the drainage area indicated that the sediment in Barcroft Reservoir has been derived largely from almost imperceptible sheet erosion, and to a very minor extent from stream-bank and gully erosion. A comparison of the two main arms of the reservoir with respect to sediment volume and drainage area revealed that the Holmes Run arm above the forks contains about $4\frac{1}{2}$ acre-feet of sediment for each square mile of drainage area, whereas the Tripps Run arm contains nearly 6 acre-feet per square mile, despite the fact that it had only about half the original capacity of the Holmes Run arm (table 1). These figures are exclusive of the deposits below the forks, which cannot be apportioned between the two individual drainage areas. It is evident from these data that sediment production has been much more rapid in the Tripps Run drainage area than in that of Holmes Run. This fact is in harmony with the character of the two areas, of which the Tripps Run drainage area includes the greater part of the cultivated and urban areas within the reservoir watershed, and the Holmes Run area is extensively wooded.

CONCLUSIONS

The sedimentation survey of Barcroft Reservoir revealed that 85 acre-feet of sediment had accumulated at an average rate of 3.7 acre-feet per year, which is equivalent to about 17.5 cubic feet a year per acre of drainage area. Silting had reduced the original storage capacity by 4.60 percent at an average rate of 0.20 percent per year. These rates are considerably below the average for reservoirs in the Southeastern States.

Although the above rates indicate that silting in the reservoir, as well as erosion in the tributary area, is not a particularly serious problem at the present time, they also show that even under the exceptionally favorable conditions existing in this area erosion and silting are progressing at measurable rates. Furthermore, certain conditions observed in the drainage area, particularly the inherent erodibility of the soils as shown by the speed with which erosion has progressed in exposed places, suggest that the present rates of erosion and silting are not necessarily permanent, but are potentially susceptible to marked acceleration. Likely causes of such acceleration are the development of gullies in unprotected roadside ditches, and the clearing and cultivation of additional areas, particularly sloping land. These possibilities should be

kept in mind by those interested in the permanency of Barcroft Reservoir as a source of municipal water supply.

The quantitative results of the sedimentation survey of Barcroft Reservoir are summarized in the tabulation on the following page.

Summary of data on Barcroft Reservoir, Alexandria, Va.

	Quantity	Unit
Age[1]...	23.1	Years
Watershed area[2]......................................	14.5	Sq. miles
Reservoir:		
Area at spillway stage:		
Original.......................................	115.4	Acres
At date of survey..............................	115.0	Acres
Storage capacity to spillway level:		
Original.......................................	1,847	Acre-feet
At date of survey..............................	1,762	Acre-feet
Capacity per sq. mile of drainage area:[2]		
Original.......................................	127.38	Acre-feet
At date of survey..............................	121.52	Acre-feet
Sedimentation:		
Total sediment................................	85	Acre-feet
Average annual accumulation:		
From entire drainage area..................	3.7	Acre-feet
Per 100 sq. miles of drainage area[3].....	25.7	Acre-feet
Per acre of drainage area:[3]		
By volume...............................	17.49	Cubic feet
By weight (assuming 1 cubic foot of		
sediment weighs 60 pounds)	0.52	Ton
Depletion of storage:		
Loss of original capacity:		
Per year.......................................	0.20	Percent
To date of survey..............................	4.60	Percent

[1]Storage began in January 1915; average date of survey, February 1938.
[2]Including area of lake.
[3]Excluding area of lake.

Figure 2

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H. H. BENNETT, Chief   W. C. LOWDERMILK, Associate Chief

BARCROFT RESERVOIR
HOLMES RUN AND TRIPPS RUN
FAIRFAX COUNTY
VIRGINIA

SEDIMENTATION SURVEY OF FEBRUARY 1938
G. C. DOBSON, Acting Head, Sedimentation Studies, Division of Research

Scale in feet
200 0 200 400 600

LEGEND

Spillway Crest at Date of Survey
Reservoir Area Silted above Spillway Level
R10—o-R2 Silt Range
△ 1001 Triangulation Station
② Segment Number
□ Plane Table Stations

Leland H. Barnes, In Charge of Field Survey

O-2245
6-27-38